

## 2000 CALFED Science Conference

### Session Notes

#### Hydrodynamics

Session Chair: Jon Burau

Session Notetaker: Peter Smith

*Modeling the Hydroclimatology of the Bay-Delta Watershed and Estuary* - Noah Knowles, Scripps Institution of Oceanography.

Main Issue/Problem: Are there trends in timing of inflows to the estuary? What is generating the inflows to the estuary (snowmelt or rainfall)? Are trends in inflows due to managed actions or to natural climate effects?

Approach: A long-term (1930-1998) time series of measured estuarine salinities were analyzed to examine the long-term trend in the annual salinity and runoff cycles. A physically based precipitation-runoff model of the entire bay-delta watershed was developed to study the natural partitioning of precipitation into snowmelt, evapotranspiration, and streamflow. The model was used to simulate monthly runoff for the period 1945-1995.

Key Findings: The data indicate that there was a trend toward earlier runoff during the period 1930-1970. After 1970 the trend appears to have abated. Prior to 1970 both managed actions and natural climate effects seem to have contributed to the trend toward earlier runoff in the combined (Sacramento and San Joaquin River) watershed. After 1970, managed actions, for no known reason, seemed to change away from causing early runoff. Annually, Sacramento River flow occurs mostly as direct runoff from rainfall over the northern Sierra, while San Joaquin River flow occurs mostly from the melting of snowpack in the higher-elevation, southern Sierra. This leads to a difference in the timing of the annual peak flow in the two rivers, with the Sacramento River flow peaking about two months earlier on average.

Relevance to CALFED: It is important for CALFED to understand whether any trends in runoff within the watershed are due to managed actions or natural climate effects. Restoration actions cannot be expected to undo the effects of climate change. The model described in this talk could potentially be very useful for assessing the flow-related effects of possible actions to restore the watershed.

Key points in discussion: The magnitude of the timing shift in the annual runoff cycle is about two or three weeks. The North Pacific Oscillation, while affecting

climate and runoff in California, may not be directly causing the timing changes in precipitation.

*Physically Based Watershed Model for the Upper Cosumnes Basin, California* - Levent Kavvas, UC Davis.

**Main Issue/Problem:** The authors are exploring whether a physically based rainfall-runoff model can provide accurate predictions of runoff without requiring any measured runoff data for use in calibrating model parameters. A model that is fully deterministic and does not require calibration can be readily applied to ungaged watersheds to evaluate management strategies.

**Approach:** A physically based rainfall-runoff model, developed at U. C. Davis, was applied to the 162 square kilometer Camp Creek Watershed. Camp Creek is a tributary to the North Fork of the Cosumnes River. The model requires input data on hillslope topography that is adequate to resolve the small-scale rills and gullies. The topography of the Camp Creek watershed was obtained by processing high-resolution digital elevation models (DEMs). Maps of soil type, soil depth, and soil porosity are used to estimate model infiltration and subsurface flow parameters. A validation of the model predictions was done using measured streamflow from January 1998 at the Camp Creek near Somerset gaging station.

**Key Findings:** It is possible to obtain reliable predictions of runoff without model calibration if a database of drainage basin characteristics are available on land surface topography, soils, and surface flows.

**Relevance to CALFED:** Upland processes drive the water balances in the Central Valley. The modeling approach presented provides a means to understand these processes and possibly evaluate management actions.

**Key points in discussion:** Many details on the specifics of assigning the model parameters were discussed. It was mentioned that the model presently does not include snowmelt.

*Interagency Team Calibration, Verification, and Application Specific Validation of the DSM2 Model* - Parviz Nader, DWR.

**Main Issue/Problem:** With the availability of new flow and bathymetry data in the delta, there was a need to re-calibrate the Department of Water Resources Delta Simulation Model 2 (DSM2). The DSM2 model had first been calibrated in 1997. During that calibration, simulation results were shown to be very sensitive to bathymetric data.

Approach: An Interagency Ecological Program (IEP) Project Work Team (PWT) completed an 18-month, multiple-agency and stakeholder collaborative effort to calibrate the DSM2 model. The team used new bathymetry to update the model grid and recent flow data to assess the model calibration errors. In addition to the calibration itself, the team collaborated on numerical and sensitivity testing of the model, planning calibration protocols, and setting priorities for new data collection. Over seventy individual hydrodynamics and salinity transport trial runs were done to adjust calibration parameters. Complete information about calibration results and progress was maintained on an IEP web site. Decisions involved in the calibration process were made using the web site, an email reflector, and conference calls.

Key Findings: The accuracy of the DSM2 model is quantified and significantly improved. There is greater trust and understanding of the model among modeling agencies, planners, water-project operators, and stakeholders. The limitations of the model are better understood. For example, there are limitations to a one-dimensional model related to the higher dimensional momentum transport and parameterization of bathymetry data. Limitations and gaps in measured data within the delta have also been revealed. The new (re-calibrated) model will be available for use in January 2001.

Relevance to CALFED: A more accurate and reliable model is available for studies of delta hydrodynamics. A performance benchmark of the model has been established that supports effective use of the model for planning and operations analysis.

Key points in discussion: Model predictions can be even further improved, and therefore additional calibration will be needed in the future. A validation is needed to better quantify the accuracy and limitations of the model. The PWT is preparing a “model application guide” that will be available in early 2001.

*Transport Mechanisms for Water and Scalars in the Delta* - Nancy Monsen, Stanford University.

Main Issue/Problem: This presentation explained and quantified some fundamental mechanisms that affect both water flows and scalar transport in the Delta. One important need for this information is for understanding how salinity intrusion into the Delta is controlled by freshwater inflows and tides. This information also can be used to help explain the mixing processes that affect transport of juvenile and larval fish.

Approach: Using results from a two-dimensional numerical simulation, the authors estimated cross-sectional fluxes of both water and a hypothetical scalar quantity at selected locations in the Delta. The fluxes were separated into a “mean advective flux” due to the tidally averaged flow, and a “tidal dispersive

flux” due to the tidal fluctuations about the mean flow. The magnitudes of the two were compared. Wind effects were neglected in the simulation.

**Key Findings:** Depending on the station location and magnitude of freshwater flow, either the mean advective flux or tidal dispersive flux can be the larger scalar transport mechanism in the delta. One location where the dispersive flux can be large is Threemile Slough. Significant transport of salt (or other quantities) through the slough can occur, when the net flow is small, due to the mixing related to tidal sloughing of water through the slough. In the western Delta where tidal forcing is greatest, dispersive flux, in general, was found to be larger than the advective flux.

**Relevance to CALFED:** In addition to helping achieve a better understanding of fundamental hydrodynamic transport mechanisms in the Delta, this research addresses the practical question of how much does freshwater flow and tidal mixing affect the location of the salt front in the western Delta. This has particular relevance to the concept of carriage water.

**Key points in discussion:** The discussion focused mostly on questions about the choices for model parameters and simulations illustrating the tracing of Yolo Bypass water into Suisun Bay.

*Lateral Variability in Two Channels in Suisun Bay* - Jessica Lacy, Stanford University.

**Main Issue/Problem:** Although many hydrographic measurements in the past five years have been made in the channels of Suisun Bay, most of these have involved instrument deployments at only one (or at most two) locations across the channel cross section. There are many questions that need to be answered regarding the variability of hydrographic variables across the channel cross sections. Examples are: How well does a single measurement represent the entire cross-sectional distribution of the quantity being measured? Are cross-channel gradients in density large enough to cause transverse (cross-channel) circulations that affect mixing? Do channel curvature and channel junctions affect lateral variability and, if so, by how much? Does the amount of lateral variability tell us something about the grid resolution needed for multi-dimensional numerical modeling studies and the limitations of one-dimensional (1-D) models?

**Approach:** Field studies were carried out to investigate the lateral variability in current velocities, salinity, temperature, and suspended –solids concentration in Suisun Cutoff and Snag Channel in Suisun Bay. Measurements were repeatedly taken along transects across each channel during a 12.5 hour tidal cycle. In Suisun Cutoff three cross sections were used to collect data during two days.

**Key Findings:** The lateral variability is large in both channels studied. Lateral density gradients are large enough to force two-layer transverse flows. Secondary circulation, which involves both transverse and vertical velocities, is important in both channels and changes through the phases of the tide. In Snag channel the structure of the flow is very different between ebb and flood, with more lateral variability occurring during flood. Transverse flows occurred in Snag Channel toward the inner bank near the surface and toward the outer bank near the bottom and appeared to be related to the lateral density (salinity) gradient. Late in the ebb tide this circulation reversed.

**Relevance to CALFED:** Lateral variability must be understood so as to help interpret hydrodynamic field measurements made at a single location in a channel cross-section. It also relates to the applicability of 1-D models.

**Key points in discussion:** In Suisun Bay, a horizontal resolution of 20 m may be needed for modeling to properly resolve the lateral variability.

*Delineation of Mixing and Flow Distribution in the Delta Using Elemental Tracers and Numerical Modeling* - Susan Paulsen, Flow Science Inc.

**Main Issue/Problem:** How do waters from the Sacramento River, the San Joaquin River, and San Francisco Bay mix in the Delta? What are the relative proportions of source waters from these three systems at locations in the Delta? How is the mixing of source waters affected by gate operations, flow barriers, and magnitudes of flows?

**Approach:** The distributions of waters from the three major sources in the Delta (the Sacramento River, the San Joaquin River, and San Francisco Bay) were studied using two independent methods. One method used naturally occurring elemental tracers (sodium, magnesium, calcium, and strontium), and the other method used numerical modeling with the Fischer Delta Model. Sampling for the tracer method was done at five locations: at the three boundaries of the Delta and at two interior locations (Bethel Island and Clifton Court Forebay). In the tracer study, sodium was used as a surrogate for salinity.

**Key Findings:** The results from the field data and numerical model agreed well at both Clifton Court Forebay (CCF) and Bethel Island. From 40-90 percent of the water at CCF originates from the Sacramento River; the remainder originates mostly from the San Joaquin River, with only a small fraction originating from San Francisco Bay. Opening the Delta Cross Channel (DCC) significantly increases the amount of Sacramento River water that reaches the south Delta. Flow barriers in the south Delta strongly impact the distribution and amount of San Joaquin River water in the south Delta. A “slug” of San Joaquin River water comes to the pumps when south-Delta barriers are removed. Results at Bethel

Island indicated that San Francisco Bay did contribute source water during the high flows of the 1997 New Year's flood.

Relevance to CALFED: This work has significant implications for operating the DCC and for installing and removing south Delta barriers so as to properly manage Delta water quality and to protect biological resources, while at the same time meeting water supply needs.

Key points in discussion: Sources of water and salts can be much different in the delta.

*Suspended-Sediment Supply to the Delta from the Sacramento River* - David Schoellhamer, U. S. Geological Survey, Sacramento.

Main Issue/Problem: What are the sources and loads of suspended sediments that enter the Delta? Is sediment-supply sufficient for the needs of habitat restoration and levee maintenance and construction?

Approach: Long-term records of measured daily suspended-sediment concentration (SSC) were analyzed at the Sacramento River at Freeport and the San Joaquin River near Vernalis. Continuous measurements of SSC (with optical instruments) were analyzed at five within Delta sites during the water year 1999.

Key Findings: The Sacramento River is the primary supplier of suspended sediment to the Delta. It has an order of magnitude greater suspended sediment load than the San Joaquin River. During the period 1955-2000 there has been a general decreasing trend in SSC that has no obvious explanation. There appear to be two distinct sources of sediment measured at the Sacramento River at Freeport. One source is local channel sediments; the other is watershed-derived sediment advected down the river from far upstream. These two sources of sediment cause a double peak in the SSC measured at Freeport during a typical pulse-flow event. Flow early in the rain season always carries proportionally more sediment than flow later in the season. The travel time of sediment from Freeport to Vernalis is close to one day. Sediment deposition occurs between Freeport and Rio Vista, most likely because of channel widening and the change in flow direction from unidirectional to bi-directional. Overall, suspended sediment supplies to the Delta do not appear to be large enough to support creation of new large areas of shallow water habitat.

Relevance to CALFED: Large quantities of sediment may be needed for planned habitat restorations and levee maintenance and construction in the Delta. It is important to monitor how much sediment is supplied naturally to the Delta to determine if the requirements for sediment can be met.

*Bedform Movement in Threemile Slough Near the San Joaquin River* - Randal Dinehart, USGS.

Main Issue/Problem: What are the bedforms like in Threemile Slough near the shoal at the confluence with the San Joaquin River? What direction are bedforms moving? What is the bedload transport rate?

Approach: Bedforms at the south end of Threemile Slough were surveyed periodically between 1998 and the present using a small boat equipped with a differential GPS receiver and depth sounding equipment.

Key Findings: Sand dunes exceeding 3 meters in height were found in the surveyed reach, indicating high rates of bedload transport and large flow resistance. At high flows during February 2000, the bedforms were all observed to move southward from the Sacramento River to the San Joaquin River. During lower flows the bedform movement can be bi-directional. A bedform transport rate of 100 tons/day was calculated as moving into the San Joaquin River during the high flow period of February 18-25, 2000. Flood flows on the Sacramento River can actually transport sediment through Threemile Slough to the San Joaquin River during a single tidal cycle.

Relevance to CALFED: Determination of sediment bed load is needed to combine with suspended sediment load to estimate total sediment load. Knowledge of bedform size is needed for estimating the roughness coefficients for mathematical models. Bedload transport is mostly responsible for the formation of shoals in the Delta. Knowledge of the direction of bedform movement is valuable as an indicator of the tidally averaged flow direction in a channel.

Key points in discussion: Bedload transport is ordinarily an order of magnitude smaller than suspended-sediment transport, but is the major mechanism by which sand particles move in the Delta.

*Sediment Bed Flux Measurements in Suisun Cutoff* - Matthew Brennan, Stanford University.

Main Issue/Problem: How and when does sediment resuspension occur in Suisun Cutoff?

Approach: Near-bed water velocity, suspended-sediment concentration (SSC), and turbulent sediment flux were measured continuously for an 8-day period in October 1999 at a site in Suisun Cutoff. Velocities were measured at heights approximately 0.5 and 1.0 meters above the bed using acoustic Doppler velocimeters. Suspended-sediment concentrations were estimated

simultaneously with optical and acoustic backscatter intensity methods. Using the velocity and concentration measurements, turbulent sediment fluxes were estimated.

**Key Findings:** Bed sediments at the study site eroded more easily during the first two hours of the flood tide. This time-dependent erodibility could be due to a greater resistance of the bed to erosion caused by higher salinity or to the longer slack-tide period that occurred before ebb flows. The greater density stratification observed on the ebb tides also may have reduced the sediment resuspension by suppressing turbulent eddies. Tidal currents and estimated bed shear stress at the study site were found to be flood dominated. Over the 8-day study period it was estimated that the bed sediment flux was landward.

**Relevance to CALFED:** This type of study is important for understanding how sediment is redistributed in Suisun Bay.